



ACCURACY IMPROVEMENT THROUGH THE USE OF ELECTRONIC DISCHARGE MACHINING INSTEAD OF CONVENTIONAL MACHINING

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ABSTRACT

In this empirical study, at first conventional machining process been carried out for making a Blind-hole (very fine) in harder material such as 20mncr5 with the help of boring tool and there after measurement have taken. All the data have been plotted in the statistical quality control (SQC) chart. There after the same work has been carried out in Electrical Discharge Machining (EDM) processes through "Cu" as an electrode & measurement has been taken as well as the data's have been plotted in the SQC chart. A remarkable improvement has been observed in terms of accuracy of the work which has been shown in the graph. So, instead of using conventional machining process we shall use Non-conventional machining process for getting higher Metal Removing Rate (MRR), along with achieving higher accuracy in terms quality of the work.

KEYWORDS: Accuracy, conventional, specification, tool wear, sophisticated.

1. INTRODUCTION:

Technology has been used to make every aspect of our lives easier. Factory mechanization is at present expected to improve quality, Productivity and safety in the production industry. By using Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) in manufacturing process it improves not only the quality of the product but also accuracy of the product.

Applications of CAD/CAM are being used worldwide to increase quality, accuracy, to increase productivity and meet the production requirement. Computer Aided Design, computer aided manufacturing, computer integrated manufacturing are the different aids been used in modern industry.

If we want to achieve greater accuracy for a product with maximum material removing rate (MRR) then we shall use non-conventional machining process instead of conventional machining process. This non-conventional machining process one of them include Electrical Discharge Machining process with help of "Cu" as an electrode as the work piece or job is smaller & for bigger job graphite is used. The different types of non-conventional machining processes are as follows

- Wire type EDM.
- Electrode type EDM.
- Ion Beam Machining.
- Electro Chemical Machining.
- Abrasive Jet Machining.

The word of non-conventional is used in sense that where such type of metal removing process cannot be applied in convention process, there the non-conventional process been applied. Use of non-conventional machining or advantages of non-conventional machining are:-

Electrical energy can be used directly to form a material in shape and size.

In some non-conventional method the tool does not come in contact with work piece and practically no wear takes place and thus fine finished product is obtained.

Precision component can be manufactured, where conventional methods cannot be employed.

Unconventional machining is not limited by hardness, toughness, brittleness of the materials.

Sometimes small erosion of particular shape is required on work piece which can be easily be done by unconventional methods of machining process.

Unconventional machining can be used for drilling circular or non-circular holes in very hard materials such as stones, ceramics, and carbides materials etc,

Some times higher material removal rate can be obtained by unconventional methods of machining, i.e. Heat treated materials can also be machined by using

conventional methods.

Very thin section of work piece can also be machined.

Printed circuits can be produced where basic connection of circuits, consist of very thin metal strips attached into insulating base.

In some of the unconventional methods of machining maintenance cost of tooling is totally been eliminated

1.1. Electrical discharge machining (EDM):

Sometimes colloquially also referred to as **spark machining, spark eroding, burning, die sinking, wire burning or wire erosion**, is a manufacturing process whereby a desired shape is obtained using electrical discharges (sparks). Material is removed from the work piece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is called the tool-electrode, or simply the "tool" or "electrode", while the other is called the work piece-electrode, or "work piece".

Advantages and disadvantages:

Advantages of EDM include machining of:

- Complex shapes that would otherwise be difficult to produce with conventional cutting tools.
- Extremely hard material to very close tolerances.
- Very small work pieces where conventional cutting tools may damage the part from excess cutting tool pressure.
- There is no direct contact between tool and work piece. Therefore delicate sections and weak materials can be machined without perceivable distortion.
- A good surface finish can be obtained; a very good surface may be obtained by redundant finishing paths.
- Very fine holes can be attained.
- Tapered holes may be produced.

Disadvantages of EDM include:

- The slow rate of material removal.
- Potential fire hazard associated with use of combustible oil based dielectrics.
- The additional time and cost used for creating electrodes for ram/sinker EDM.
- Reproducing sharp corners on the work piece is difficult due to electrode wear.

- Specific power consumption is very high.
- Power consumption is high.
- "Overcut" is formed.
- Excessive tool wear occurs during machining.
- Electrically non-conductive materials can be machined only with specific set-up of the process.

Wire EDM:

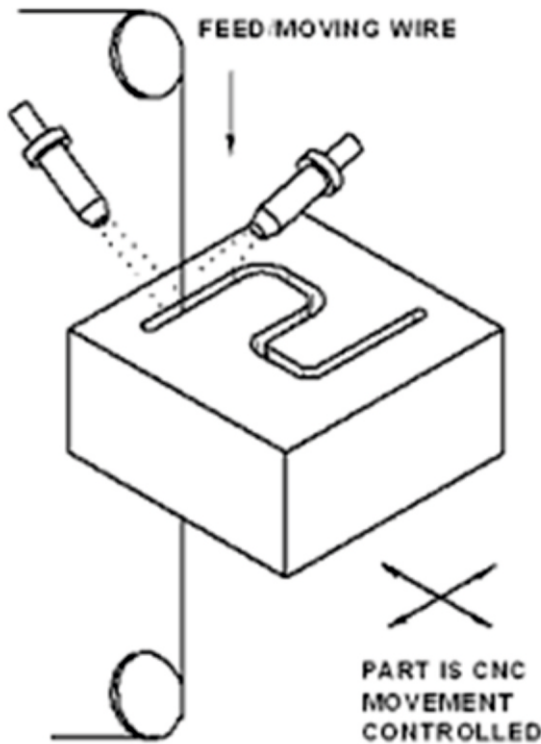


Fig1: CNC Wire-cut EDM machine

Dies from hard metals that are difficult to machine with other methods. The wire, which is constantly fed from a spool, is held between upper and lower diamond guides. The guides, usually CNC-controlled, move in the x-y plane EDM is typically used to cut plates as thick as 300mm and to make punches, tools. On most machines, the upper guide can also move independently in the z-u-v axis, giving rise to the ability to cut tapered and transitioning shapes (circle on the bottom, square at the top for example). The upper guide can control axis movements in x-y-u-v-i-j-k-l-. This allows the wire-cut EDM to be programmed to cut very intricate and delicate shapes. The upper and lower diamond guides are usually accurate to 0.004 mm, and can have a cutting path or kerfs as small as 0.021 mm using Ø 0.02 mm wire, though the average cutting kerfs thin wire *electrical discharge machining* (WEDM), also known as wire-cut EDM and wire cutting, a thin single-strand metal wire, usually brass, is fed through the work piece, submerged in a tank of dielectric fluid, typically de ionized water. Wire-cut at achieves the best economic cost and machining time is 0.335 mm using Ø 0.25 brass wire. The reason that the cutting width is greater than the width of the wire is because sparking occurs from the sides of the wire to the work piece, causing erosion. This "overcut" is necessary, for many applications it is adequately predictable and therefore can be compensated for (for instance in micro-EDM this is not often the case). Spools of wire are long — an 8 kg spool of 0.25 mm wire is just over 19 kilo meters in length. Wire diameter can be as small as 20 micrometers and the geometry precision is not far from +/- 1 micrometer. The wire-cut process uses water as its dielectric fluid, controlling its resistivity and other electrical properties with filters and de-ionizer units. The water flushes the cut debris away from the cutting zone. Flushing is an important factor in determining the maximum feed rate for a given material thickness. Along with tighter tolerances, multi axis EDM wire-cutting machining centers have added features such as multi heads for cutting two parts at the same time, controls for preventing wire breakage, automatic self-threading features in case of wire breakage, and programmable machining strategies to optimize the operation. Wire-cutting EDM is commonly used when low residual stresses are desired, because it does not require high cutting forces for removal of material. If the energy/power per pulse is relatively low (as in finishing operations), little change in the mechanical properties of a material is expected due to these low residual stresses, although material that hasn't been stress-relieved can distort in the machining process. The

work piece may undergo a significant thermal cycle, its severity depending on the technological parameters used. Such thermal cycles may cause formation of a recast layer on the part and residual tensile stresses on the work piece. If machining takes place after heat treatment, dimensional accuracy will not be affected by heat treat distortion.

1.2. Electrode(Cu/Graphite)EDM(Sinker EDM):-

Sinker EDM, cavity type consists of an electrode and work piece and merged in a insulating liquid. The electrode & work piece are connected to a suitable power supply. This power supply generates an electrical potential between the two parts. If the electrode approaches the work piece, dielectric break down occur in the fluid, forming a plasma channel and a small spark jumps.

Types of EDM Electrode Materials:

Brass, Copper, Copper, Tungsten, Graphite, Molybdenum, Silver, Tellurium .



Fig-2. Irregular design job using graphite EDM

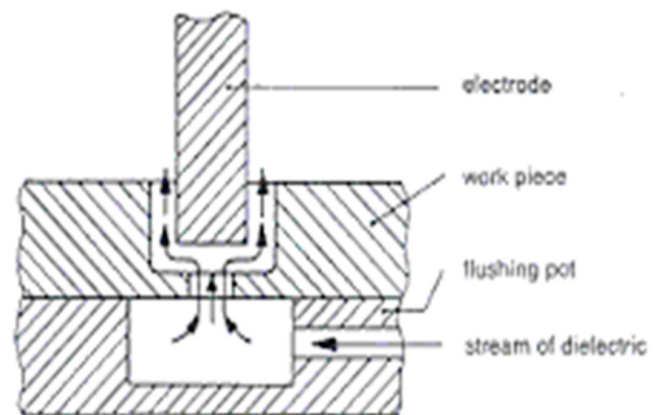


Fig.3 pressure flushing through the work piece

Expression for Material Removal Rate (MRR):

$$MRR = 4 \times 10^{-4} I \cdot T_w^{-1.23} \text{ mm}^3/\text{min}$$

T_w = melting point of the work piece in $^{\circ}\text{C}$.

I = current in Amp

Hence the rate of EDM " W_r " can be estimated from $w_r = 1.1 \times 10^{-11} I \cdot T_i^{-2.38}$. Where " w_r " is in mm^3/min . T_i is the melting point of electrode material in $^{\circ}\text{C}$, the wear ratio of the work piece to electrode "R" can be estimated. by the equation $R = 2.25 T_i^{-2.38}$ where " T_i " is the ratio of work piece to the electrode MRR from 2 to 400 mm^3/min .

Note:

1. High rates produce rough finish.
2. Finishing cuts are more at low MRR

Oscillating electrode produces very fine surface finish & requiring sufficiently less béchamel to improve lustrous cavities.

Flushing:

1. The circulation of Die-electric fluid between electrode & the work piece is called flushing.

2. Complex shape electrode with sharp edges or protruding point produces poor accuracy.
3. Surface finish of 0.4u. With no wear machining, the surface finish up to 3.2u can be achieved.

1.3. STATISTICAL QUALITY CONTROL (SQC) CHART:-

SQC (Statistical Quality Control) chart consisting of three horizontal lines which has drawn on graph, Hence X-axis shows the no. Of observations & Y-axis shows the quality characteristics of the work. Hence upper line known as Upper Specification Limit (USL) and middle line known as specification limit and the lower horizontal line known as Lower Specification limit.

1.4 ANALYSE THE DATA:

All these data shall be plotted in the statistical quality control chart and the tradition of the chart shall be observed for both conventional machining process as well as non-conventional machining process (EDM).

2. JOB 1. BORING OPERATION WITH BORING TOOL:- (Conventional Process)

JIG BORING:-

- A Jig borer is suitable for producing higher accuracy of drilling, boring operation. Hence the machine is designed for location accuracy and heavy material removal. Generally used to make the blind hole.

MACHINE SPECIFICATIONS:-

- 0.0001 J>Machine used is Jig borer machine.
- Jig borer has a work table of around 400 x 200 mm.
- Positional accuracy inch i.e. 2.25 micro meter.

Metal used for blind hole making:- 20 mncr5

Depth of Cut = 5 ± 0.1 mm, where USL=5.1mm, SL=5mm, LSL=4.9mm.

Hole diameter = $\phi 18 \pm 0.1$, Where USL=18.1mm, SL=18mm, LSL=17.9mm.

1st Operation:-

- Making Pilot hole.
- Drilling operation of diameter 16mm and up to 4 mm depth of cut.

2nd Operation:-

- End mill operation up to depth of 5mm.
- Boring operation up to $\phi 18$.

Process:-

> Making pilot hole with center drill size 1.5 mm.

> Step drill operation carried out with the help of even size drills in step of 2. i.e. 2, 4, 6, 8, 10, 12, 14, 16.

> End mill operation with the help of 4 fluted HSS End mill Cutter up to 5mm depth of cut

> Boring operation with the help of boring tool up to $\phi 18$ mm.

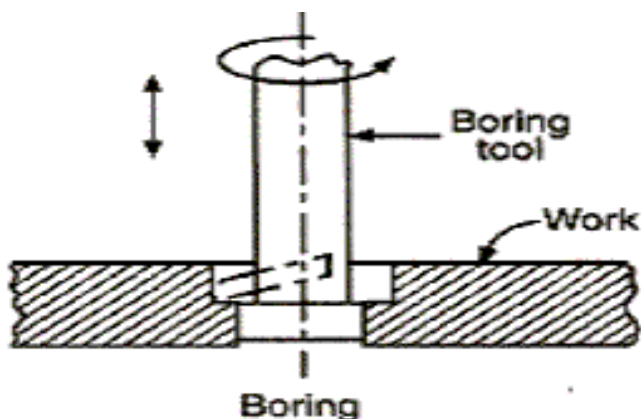


fig:-4. Boring operation with boring tool

3. TAKING MEASUREMENT WITH HELPOF BORE DIAL GAUGE:

- Bore dial gauge is used for measuring the dimensions.
- Depth gauge is used for measuring depth of the blind hole.

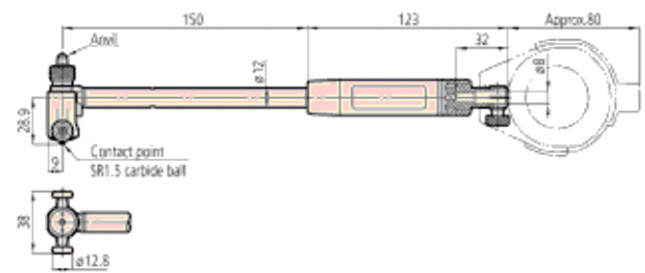


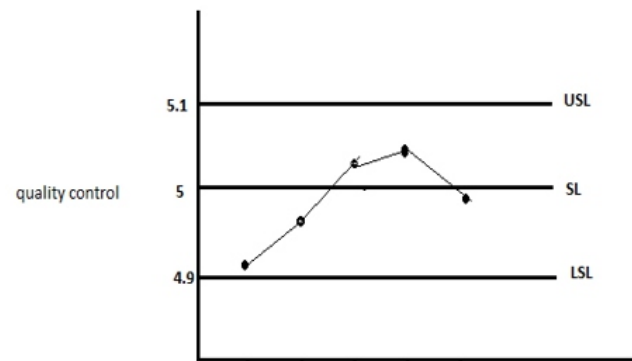
Fig:-6. Bore dial gauge

Data after measurement:-

Depth: - 4.92mm, 4.95mm, 5.5mm, 5.53mm, 4.98mm

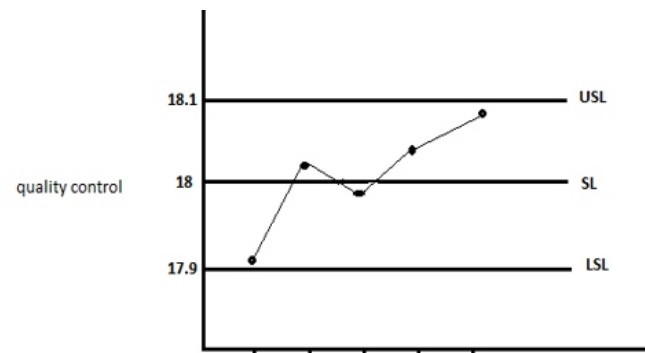
Diameter: 17.92mm, 18.02mm, 17.95mm, 18.05mm, 18.08mm.

GRAPHS:



no. of observations

SQC chart1 for depth



no. of observations

SQC chart 2 for diameter

3rd Operation:

4. BORING OPERATION WITH HELPOf (CNC) EDM:

PREPERATION OF ELECTRODE:

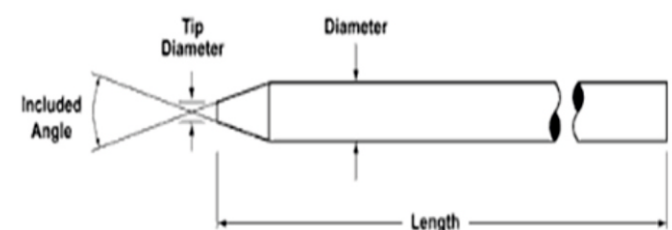


Fig.8. preparation of electrode

- Selection of copper rod diameter as per the specification with respect to the job as electrode. Cu rod $\phi 20$ mm and length 10.5 mm as raw material.

- Facing operation done for making correct length of copper electrode of 10mm.
- For getting exact diameter, turning operation done in a CNC machine for getting diameter of 17.75 mm
- Tip the electrode made with an angle of 45° as shown in fig 8.
- Making electrode in CNC turning machine operation for length up to 10 mm with after facing, diameter of 17.75mm after turning operation.

PREPERATION OF EDM MACHINE WITH PROGRAMMING:

- Check the service capability of the machine.
- Fix the electrode (Cu) & check electrolytic condition & heights in the machine.
- Fix the work piece in the machine bed.
- Do the programming of the machine for the work to be performed.
- Ensure the proper tool/electrode (Cu) position with respect to the machine axis with work with the help of tool re-setter.
- Ensure job/work should be totally inside the liquid (electrolyte).
- Before putting "ON" for the operation, ensure that die-electric/electrolyte is fresh & free from other impurity.

NOTE:-

Temperature of the Di-electric should not be increased to avoid "craters".

OPERATION:

Once programming has been done in the EDM machine, put the s/w on for performing the operation automatically & once machine & stats doing the operation by metal removing process it finishes the required dimensions. i.e. depth of cut. This can be observed in the computer graphic in the machine for how much depth of cut and position of Cu electrode etc. Once the job is finish, machine automatically stops. There after switch off & take out the work piece from the machine bed when all the Di-electric fluid drains out.

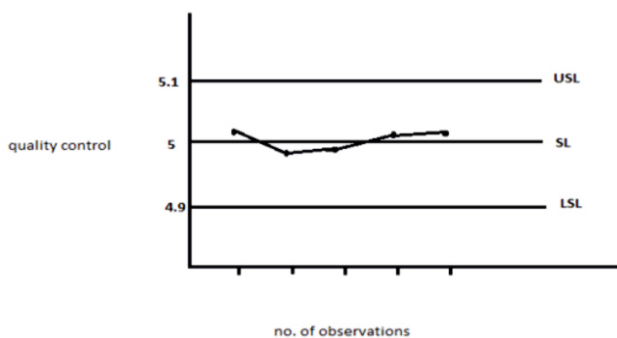
MEASUREMENT WITH HELPOFBORE DIAL GAUGE:

DATA COLLECTION:

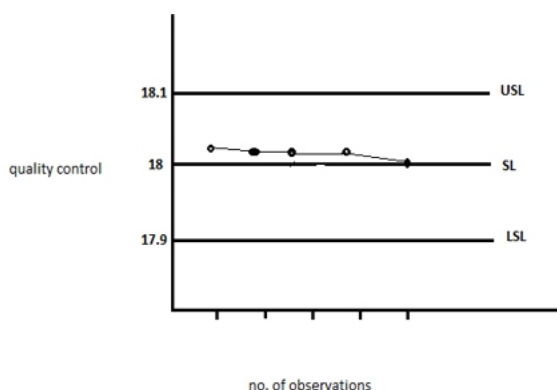
For diameter and Depth, the data are:

Depth:- 5.02mm, 4.98mm, 4.99mm, 5.05mm, 5.00mm

Diameter:- 18.035mm, 18.025mm, 18.034mm, 18.038mm, 18.034mm , 18.00mm



SQC chart 3 for depth



SQC chart 4 for diameter

OBSERVATION:

It has been observed from the SQC chart that boring operation with boring tool. The specific limit of variability is more both for hole dimension and for depth of cut also.

Hence in case of after EDM process the SQC chart shown that the dimension received after measuring are closed to the mean value i.e., trend towards the specification limit, that is specific variability is less.

EDM process metal removal rate (MRR) is high of harder material with fine surface finesse.

By comparing both the conventional and non conventional process with SQC charts, CNC, EDM process given better in quality in terms of accuracy of the product.

CONCLUSION:

Use of non-convention machining process produces better quality work through MRR (metal removing process). So for detaining sophisticated product, EDM process shall be used, especially for irregular shape. Hence for sophisticated work we achieved the high accuracy and quality of the product; in turn we get the higher productivity.

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